

Part 2 -- Remarks

This Amendment and Response is responsive to the final office action mailed October 22, 2003. In that office action, the amendment filed July 22, 2003 was objected to under 35 U.S.C. 132 for introducing new matter into the disclosure; claim 1 was rejected under 35 U.S.C. 112, first paragraph, for failing to comply with the written description requirement; claim 1 was objected to for informalities; claims 1, 3 and 4 were rejected as obvious under 35 U.S.C. 103(e) over Uglow (6,251,770) and further in view of Chooi (6,284,657); claims 2 and 5 were rejected as obvious under 35 U.S.C. 103(a) over Uglow in view of Swanson (6,103,590) as applied to claim 1, and further in view of Conboy (5,904,487) and Bhardwaj (6,051,503); claims 6, 7, 9 and 10 were rejected as obvious under 35 U.S.C. 103(a) over Uglow as applied to claim 1, and further in view of Swanson; and claims 8 and 11 were rejected as obvious under 35 U.S.C. 103(a) over Uglow in view of Swanson as applied to claim 6, and further in view of Conboy and Bhardwaj.

Reconsideration of these objections and rejections is respectfully requested, with respect to the pending claims 1-11.

New Matter Objection and Rejection

Reconsideration of the new matter objection to the July 22, 2003 amendment, and the written description rejection of claim 1 under 35 U.S.C. 112 is respectfully requested.

Claim 1 was amended in the July 22, 2003 amendment to further define that an exposed low dielectric constant (low k) material layer is adjacent to the silicon carbide (SiC) layer. The October 22 office action asserts that this amendment is new matter because it is not described in the specification or depicted in the drawing. The October 22 office action specifically refers to page 2, lines 22-28 of the specification as lacking in disclosure of this material.

Page 2, lines 22-28 of the specification does not disclose the amendment in the July 22, 2003 amendment and response. However, the subject matter of the previous amendment is disclosed elsewhere in the specification and the drawing as originally filed. Specifically, page 5, lines 5-8 discloses: "In order not to erode or otherwise

damage the exposed sidewalls 126 and 128 of the second and first low k type material films 112 and 110, respectively, the improved SiC etch process described herein is used to etch away the exposed portion 130 of the first SiC film 104.” Also, page 5, lines 26-29 reads: “In other words, the rate at which the exposed portions of the SiC films 104 and 106 are etched away is increased relative to the rate at which the exposed portions of the low k type material films 110 and 112 are eroded by the SiC etch process.” Additionally, Fig. 1 shows the exposed sidewalls 128 of the low k material film layer 110 adjacent to the exposed portion 130 of the first SiC film 104.

The specification therefore contains an original disclosure of a semiconductor wafer with an exposed low dielectric constant material layer adjacent to the silicon carbide layer. This subject matter is not new matter, because it was contained in the application as originally filed. Accordingly, it is believed that the new matter rejection and the written description rejections are erroneous and should be withdrawn.

Claim Objections

Regarding the objection to claim 1, line 8, “carbon-tetrafluoritde” has been changed to the correct spelling “carbon-tetrafluoride.” This amendment is believed to resolve the objection.

Obviousness Rejections

The obviousness rejection of claims 1, 3 and 4 based on Uglow in view of Chooi is believed to be based on Uglow in view of Swanson since the reasoning for the rejection discusses Swanson and not Chooi and because the dependent rejection of claims 2 and 5 refers to the rejection as one based on Uglow in view of Swanson. Accordingly, this response addresses a rejection based on Uglow in view of Swanson.

If the obviousness rejection is intended to be based on Uglow in view of Chooi, the reasoning for the rejection is missing from the October 22, 2003 Office Action, and therefore that rejection is insufficient. Under such circumstances a new office action must be issued.

Reconsideration of the obviousness rejection of claims 1, 3 and 4 based on Uglow in view of Swanson is respectfully requested.

The present invention generally relates to the removal of an exposed silicon carbide (SiC) layer from an underlying layer of copper without substantially removing

an exposed low dielectric constant (low k) material that is adjacent to the SiC layer. The etch used for the removal has a selectivity to the SiC layer relative to the low k material so that much more SiC is removed than low k material, thereby stripping the SiC from the copper without substantially removing the low k material.

Uglov is generally related to the removal of a dielectric material from an underlying SiC layer without removing the SiC layer. Uglov discloses using layers of materials with different dielectric constants in inter-metal dielectric structures to reduce the inter-metal capacitance and thereby increase the speed of dual damascene structures. To achieve lower inter-metal capacitance, Uglov uses low k dielectric materials such as carbon doped silicon dioxide (C-oxide), that is partially organic and partially inorganic, and purely inorganic dielectrics such as silicon dioxide. C-oxide has a lower dielectric constant than silicon dioxide. See Uglov column 1, lines 35-38.

Uglov has a SiC layer over a copper layer to protect the copper layer while the inter-metal dielectric layers are etched. However, Uglov does not use a low k material adjacent to the SiC layer because Uglov has difficulties with etching the low k material from the SiC. As illustrated in Fig. 1, Uglov does not have the low k material adjacent to the SiC barrier layer because the etchant used by Uglov for the low k material also etches through the SiC barrier layer to prematurely expose the underlying copper. Prematurely exposing the copper can cause the copper to be deposited on the walls of the dielectric in the via holes, thereby increasing the overall inter-metal capacitance and reducing the speed of the structure. See column 1, lines 66-67 to column 2, lines 1-15. So that the SiC layer is not prematurely removed, Uglov uses an inorganic via dielectric layer adjacent to the SiC layer and a low k trench material on top of the via dielectric layer. See column 2, lines 35-43, lines 45-51, lines 60-67; and column 3, lines 1-7. When the inorganic via dielectric layer of Uglov is etched, the SiC layer remains intact to protect the copper layer, since etchants are able to remove the inorganic via dielectric layer while leaving the organic SiC layer.

Uglov does not disclose etching an exposed SiC layer from an underlying copper layer without substantially removing an exposed low dielectric constant material. While Uglov discloses removing the barrier layer 102a of SiC to expose the copper material 122, (Column 5, lines 63-67 and column 6 lines 1-9), this is disclosed

where a via dielectric layer 104 of inorganic oxide materials is adjacent to the barrier layer, not low k dielectric material. See column 5, lines 48-50. Low k material is used in the trench dielectric layer 106, above the via dielectric layer. "It is important to note that the material properties of the trench dielectric layer 106 are different than that of via dielectric layer 104." See column 5, lines 1-14 and column 4 lines 66-67 to column 5 line 1.

As more specifically set forth in the claims, the present invention involves etching SiC without substantially removing the low dielectric constant material that is adjacent to the SiC layer. Uglow, on the other hand, involves etching a low dielectric constant material from a SiC layer. Thus, the present application removes the SiC while leaving an adjacent low dielectric constant material, while Uglow removes a dielectric material while leaving the SiC layer. The concepts of the present invention and Uglow appear to be the reverse or opposite of one another. Therefore, Uglow does not appear to suggest the subject matter of the present application, and Uglow appears to be lacking both the disclosure and suggestion of etching an exposed silicon carbide layer from an underlying copper layer without substantially removing an exposed low dielectric constant material as is required in the manner set forth in claim 1.

Claim 1 further requires, in the manner set forth, flowing an etch chemical into contact with the SiC and low dielectric constant material layers, the etch chemical selected from the group consisting of CF₄, CHF₃, CH₂F₂ and CH₄, and introducing H₂ or NH₃ into the flow of the etch chemical to enhance the selectivity of the etch chemical to the SiC layer relative to the low dielectric constant material layer.

Swanson discloses a method of forming porous silicon regions in a silicon substrate by using a masking layer of SiC that is patterned and etched to expose the region in the substrate where the porous silicon is desired. While Swanson discloses methods of removing portions of the SiC masking layer from a substrate which use CF₄, CHF₃ and H₂, Swanson does not disclose using these chemicals to remove SiC from a copper layer, or removing SiC without substantially removing an exposed low dielectric constant material as is required in the manner set forth in claim 1. Swanson also does not disclose using H₂ or NH₃ to increase the selectivity of the etch chemical

to the SiC layer relative to the low dielectric constant material, Swanson does not mention low k dielectric material. Swanson discloses that a selectivity of 10:1 of SiC relative to SiO₂ can be achieved using Cl₂, but does not disclose the selectivity of CF₄, CHF₃ or H₂ with respect to any dielectric material. See column 4, lines 26-30. In addition, Swanson does not disclose the use of etch chemicals CH₂F₂, CH₄ or selectivity enhancing chemical NH₃.

Nothing in Uglow or Swanson appears to suggest combining one reference with the other. Indeed, the two references seem to suggest or teach against such a combination to accomplish etching a low k material from a SiC layer. Uglow does not involve etching SiC while leaving low k material, but rather removing a SiO₂ layer (a relatively higher k material according to Uglow column 1, lines 33-39) while leaving a SiC layer. In addition, Swanson does not disclose the selectivity of any of the chemicals, CF₄, CHF₃ or H₂ to SiC relative to a low k material, or any other dielectric. Therefore, there appears to be no suggestion for combining Uglow and Swanson. Without some suggestion to combine the references within those references themselves, the combination of references must be regarded as based on hindsight gained from the applicant's disclosure. The use of hindsight as a basis for combining references is not a permitted basis for rejection.

Dependent claims 3 and 4 should be patentable in conjunction with claim 1, from which they depend, for the reasons stated above.

Reconsideration of the obviousness rejection of claims 2 and 5 based on Uglow in view of Swanson and further in view of Conboy and Bhardwaj is respectfully requested.

As discussed above, etching a SiC without substantially removing an exposed low dielectric constant material is not disclosed or suggested by either Uglow or Swanson. Conboy and Bhardwaj do nothing to disclose this missing material. Conboy involves reshaping an electrode in a semiconductor etching device, while Bhardwaj involves methods of depositing a sidewall passivation layer on etched semiconductors. Since none of Uglow, Swanson, Conboy or Bhardwaj disclose or suggest etching a SiC without substantially removing an exposed low dielectric constant material, these references cannot disclose or suggest using an etch chemical selected from CF₄,

CHF₃, CH₂F₂ and CH₄ and introducing a selectivity enhancing chemical selected from H₂ and NH₃ to etch SiC without substantially removing an exposed low dielectric constant material. Therefore, the etch chemicals CF₄, CHF₃, CH₂F₂ and CH₄ and the selectivity enhancing chemicals H₂ and NH₃ are not recognized in Uglow, Swanson, Conboy or Bhardwaj as result effective variables for etching a SiC without substantially removing an exposed low dielectric constant material.

Discovering the optimum ranges of chemical ratios, temperatures, pressures and power levels for the use of these etch chemicals and selectivity enhancing chemicals cannot be characterized as routine experimentation involving only routine skill in the art from the references cited, since these chemicals are not recognized in Uglow, Swanson, Conboy or Bhardwaj as result effective variables for etching a SiC without substantially removing an exposed low dielectric constant material. Therefore, claims 2 and 5 do not appear to be obvious over Uglow in view of Swanson, Conboy and Bhardwaj.

Reconsideration of the obviousness rejection of claims 6, 7, 9 and 10 based on Uglow in view of Swanson is respectfully requested.

The discussion of the deficiencies of Uglow and Swanson with respect to independent claim 1 and dependent claims 3 and 4 apply to claims 6, 7, 9 and 10 as well. Nothing in Uglow or Swanson appear to suggest these deficiencies, which relate to removing a region of the exposed SiC layer with the combination flow to expose a portion of the copper layer without substantially eroding the exposed portion of the low dielectric constant material. Furthermore, nothing in Uglow or Swanson appears to suggest combining one reference with the other. Without some suggestion to combine the references within those references themselves, the combination of references must be regarded as based on hindsight gained from the applicant's disclosure. The use of hindsight as a basis for combining references is not a permitted basis for rejection.

Reconsideration of the obviousness rejection of claims 8 and 11 based on Uglow in view of Swanson, Conboy and Bhardwaj is respectfully requested.

The deficiencies of Uglow, Swanson, Conboy and Bhardwaj that have been described above with respect to claims 2 and 5 also apply to claims 8 and 11.

Conclusion

For the reasons set forth above, and others, it is believed that all pending claims in this application define patentable subject matter are in condition for allowance. Allowance is respectfully requested.

If the pending claims in this application are not deemed to be allowable, then the undersigned hereby requests a telephone interview with the Examiner to discuss the reasoning behind any further objections or rejections. The Examiner is requested to contact the undersigned to schedule a time for the telephone interview if needed.

Respectfully submitted,

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